On radio emission of the Geminga pulsar and RBS 1223 at the frequency of 111 MHz

Alexander A. Ershov [1,2]

ABSTRACT

I have searched for pulsed radio emission from the Geminga pulsar and for the nearby isolated neutron star 1RX J1308.6+2127 (RBS 1223) at the frequency of 111 MHz. No pulsed signals were detected from these sources. Upper limits for mean flux density are 0.4 - 4 mJy for the Geminga pulsar and 1.5 - 15 mJy for RBS 1223 depending on assumed duty cycle (.05 - .5) of the pulsars.

1. Introduction

The gamma pulsar Geminga was discovered in 1972 with the help of SAS-2 satellite (Fitchel et al. (1975)). It is the second brightest gamma-source on the sky at energies over 100 MeV and it was investigated in all bands of electro-magnetic spectrum. Its identification as a pulsar was not secure until the detection of X-ray (Halpern & Holt (1992)) and gamma-ray pulsations (Bertsch et al. (1992)). In 1990-s three groups from Pushchino Radio Astronomy Observatory reported on discovery of pulsed radio emission from the Geminga pulsar at 102.5 MHz (Kuzmin & Losovsky (1997), Malofeev & Malov (1997), Shitov & Pugachev (1998)) with flux density from 30 mJy to 100 mJy and dispersion measure about of 3 pc cm^{-3}. But numerous searches for pulsed radio emission from the Geminga pulsar at higher frequencies had no positive results (see Kassim & Lazio (1999) and references therein). I searched for pulsed radio emission from this pulsar at the frequency of 111 MHz.

1RX J1308.6+2127 (also known as RBS 1223) is a nearby isolated neutron star (Schwope et al. (1999)) with the period of 10.3 s (Haberl (2004)), identified also as a very faint optical object (Kaplan et al. (2002)). Recently Malofeev et al. (2005) reported on discovery of pulsed radio emission from this neutron star at a frequency of 111 MHz with a mean flux density about of 50 mJy. I searched for pulsed radio emission from this neutron star as well: at the same frequency and with the same radio telescope.

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[1]Pushchino Radio Astronomy Observatory, Astro Space Center, Lebedev Physical Institute, Russia

[2]E-mail: ershov@prao.ru

2. Observations and Data Reduction

The observations were performed from November 1999 through March 2007 with the Large Phase Array (BSA) radio telescope at Pushchino Radio Astronomy Observatory with an effective area at zenith of about 15,000 square meters. One linear polarization was received. I used 128-channel receiver with a channel bandwidth of 20 kHz and a center frequency of 110.59 MHz. The observations were carried out in the mode of recording individual pulses. The sampling interval was 2.56 ms at the receiver time constant $\tau = 3$ ms for the Geminga pulsar and 5.0 ms at the receiver time constant $\tau = 10$ ms for the RBS 1223. Since BSA radio telescope is a transit one, the duration of one observing session is limited to 3.2 / $cos(\delta)$ min. A total of 600 observational sessions was carried out for each pulsar. These observations contain 441,000 pulsar periods for the Geminga pulsar and 12,000 pulsar periods for RBS 1223. Since the middle of 2004 antenna was calibrated by observations of the 3C 452 source, flux density of which at 111 MHz is considered as 91 Jy. The nearby (on the sky) pulsar PSR B0626+24 was observed as a test pulsar for the Geminga pulsar observations.

At primary processing of day observation session, a mean value was deduced from time-series in each frequency channel and a result was divided by mean square deviation of the channel. Then records were reviewed to reveal interference, namely: records of all channels were averaged without compensation for dispersion delay (as ground interferences have no dispersion delay) and if interference was revealed (with signal to noise ratio of seven or higher) then corresponding values were substituted with zero at all channels. Further: folding, that is summation of periods in record of each channel, was performed; at that, period meaning for a special day of observations was calculated on the base of recent ephemeris (Jackson & Halpern (2005), Halpern (2007) for the Geminga pulsar and Kaplan & van Kerkwijk (2005) for RBS 1223). And finally: compensation of dispersion delay was performed for each channel; at that, dispersion measure was searched in the range from 0 to 40 pc cm^{-3} with spacing of 1 pc cm^{-3}. The proposed distance (160 pc) to the Geminga pulsar corresponds to dispersion measure about of $DM = 3$ pc cm^{-3}. No statistically (signal-to-noise ratio $S/N > 5$) meaning radio emission was found in any series of observations for both pulsars.

3. Results

3.1. The Geminga Pulsar

To improve the sensitivity of the search, all 600 observational sessions were averaged together by time reference in accordance with updated ephemeris (Jackson & Halpern (2005), Halpern (2007)) and with above mentioned searches of dispersion measure. I did not reveal any significant radio emission at this processing either. Examples of resulting average (for all 600 sessions) pulse profiles for a number of dispersion measure values are presented at the Fig 1. Value of upper limit (5σ, at

smoothing to the time resolution of 10 ms) for a peak flux density equals to 8 mJy. A correspondent value of the mean (by period) upper limit is within 0.4 to 4 mJy range depending on an assumed (.05 to .5) pulse duty cycle.

Fig 2 shows profile of the Geminga pulsar (for all 600 series; smoothed by 4 points and 2 periods are presented) for dispersion measure of 3 pc cm^{-3} together with average profile of the test pulsar PSR B0626+24. The mean flux density of PSR B0626+24 is 60 mJy, that is approximately the same as was declared for the Geminga pulsar. Unfortunately, my results do not confirm results of my colleagues.

3.2. 1RX J1308.6+2127 (RBS 1223)

To improve the sensitivity of the search, all 600 observational sessions were averaged together by time reference in accordance with ephemeris from paper of Kaplan & van Kerkwijk (2005) and with above mentioned searches of dispersion measure. I did not reveal any significant radio emission at this processing either. Examples of resulting means (for all 600 sessions) of pulse profiles for a number of dispersion measure values are presented at the Fig 3. Value of upper limit (5σ) for a peak flux density equals to 30 mJy (at smoothing to the time resolution of 20 ms). A correspondent value of the mean (by period) upper limit is within 1.5 to 15 mJy range depending on a proposed (.05 to .5 period) pulse duration. Unfortunately, my results do not confirm results of Malofeev et al. (2005).

4. Conclusions

The search of pulsed radio emission from the Geminga pulsar and 1RX J1308.6+2127 (RBS 1223) at the frequency of 111 MHz give no positive results. Upper limits for mean flux density are 0.4 - 4 mJy for the Geminga pulsar and 1.5 - 15 mJy for RBS 1223 depending on assumed duty cycle (.05 - .5) of the pulsar.

5. Acknowledgements

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REFERENCES

Bertsch, D. L. et al. 1992, Nature, 357, 306

Fitchel, C. E. et al. 1975, ApJ, 198, 163

Haberl, F. 2004, Adv. Space Res., 33, 638

Halpern, J. P. & Holt, S. S. 1992, Nature, 357, 222

Halpern, J. P. 2007, private communication

Jackson, M. S. & Halpern, J. P. 2005, ApJ, 633, 1114

Kaplan, D. L., Kulkarni, S. R. & van Kerkwijk, M. H. 2002, ApJ, 579, L29

Kaplan, D. L. & van Kerkwijk, M. H. 2005, ApJ, 635, L65

Kassim, N. E. & Lazio, T. J. W. 1999, ApJ, 527, L101

Kuzmin, A. D. & Losovsky, B. Ya. 1997, Astron. Lett., 23, 323

Malofeev, V. M. & Malov, O. I. 1997, Nature, 389, 697

Malofeev, V. M. et al. 2005, ARep, 49, 242

Schwope, A. D., Hasinger, G., Schwarz, R., Haberl, F. & Schmidt, M. 1999, A&A, 341, L51

Shitov, Yu. P. & Pugachev, V. D. 1998, NewA, 3, 101

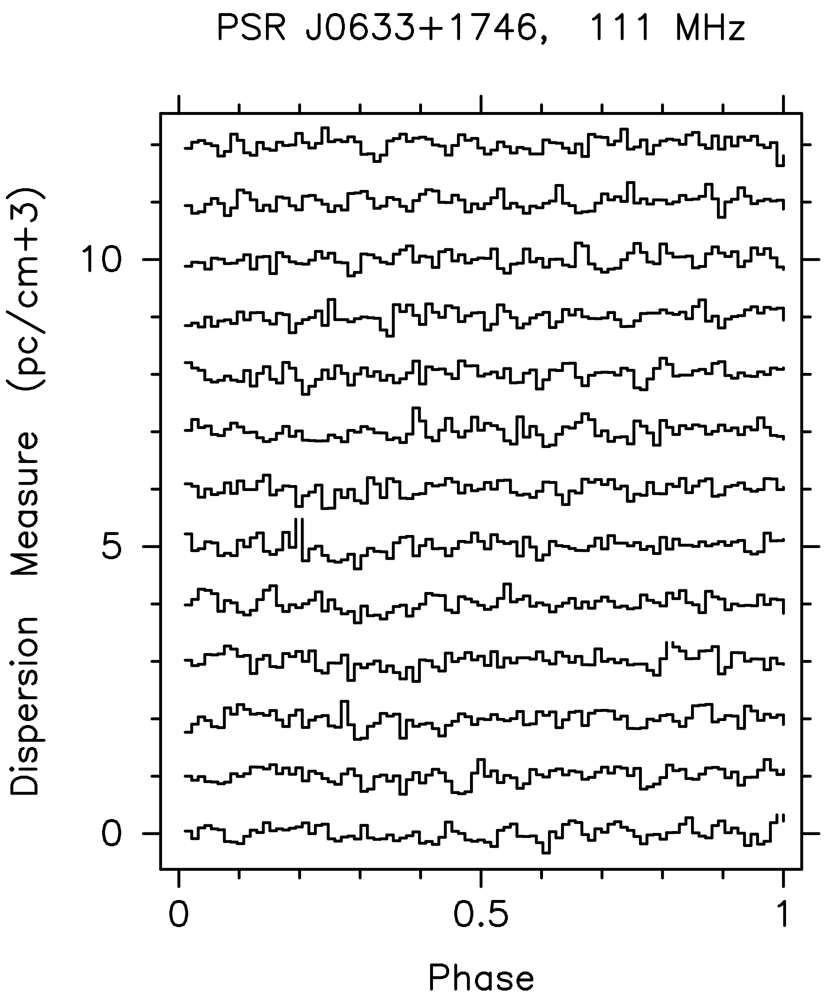

Fig. 1.— The average profiles of the Geminga pulsar at the frequency of 111 MHz for a number of dispersion measure values.

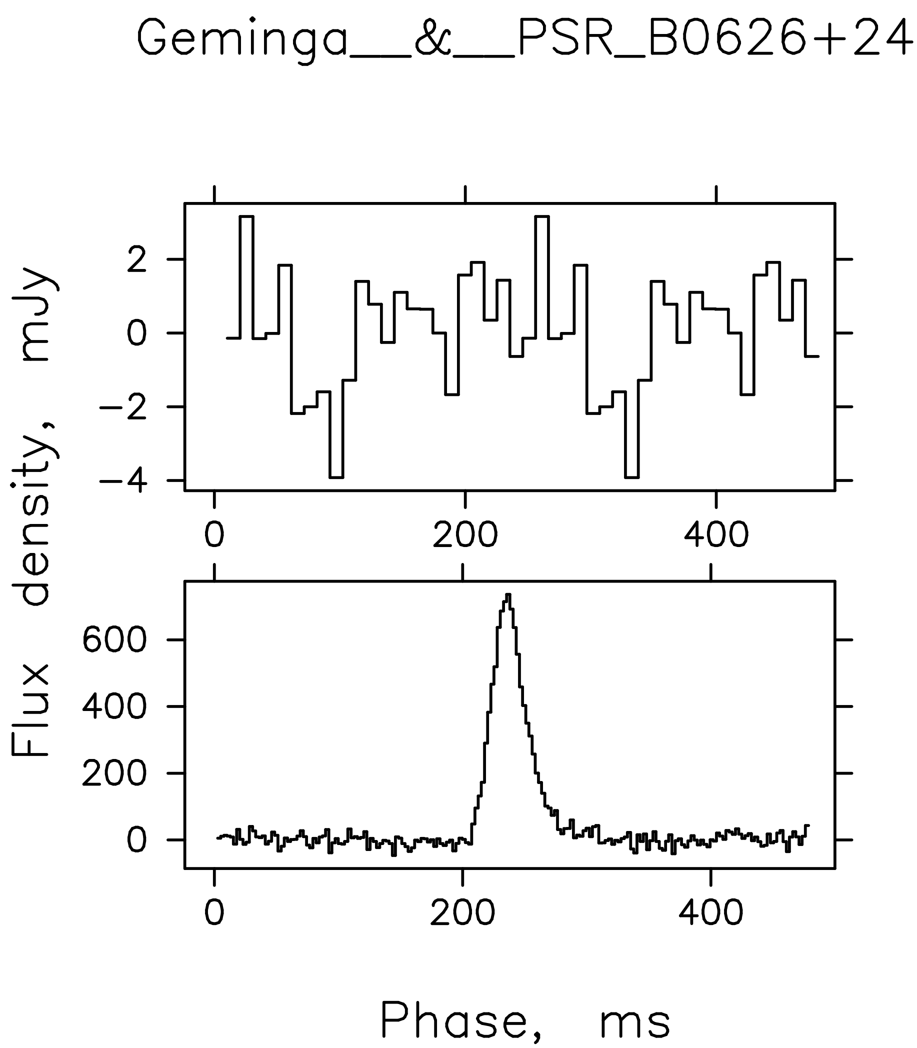

Fig. 2.— The average profile of the Geminga pulsar for dispersion measure of 3 pc cm^{-3} at the frequency of 111 MHz together with the profile of test pulsar PSR B0626+24.

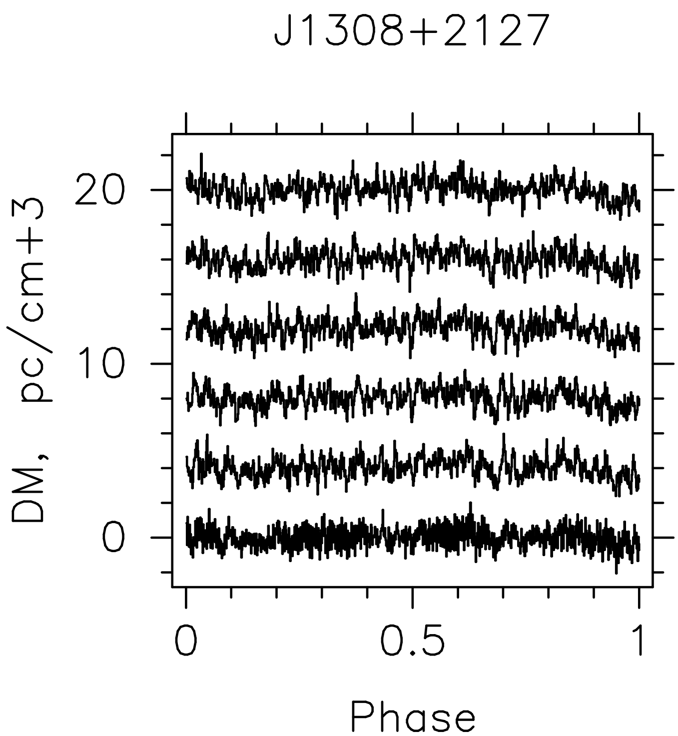

Fig. 3.— The average profiles of RX J1308.6+2127 at the frequency of 111 MHz for a number of dispersion measure values.